



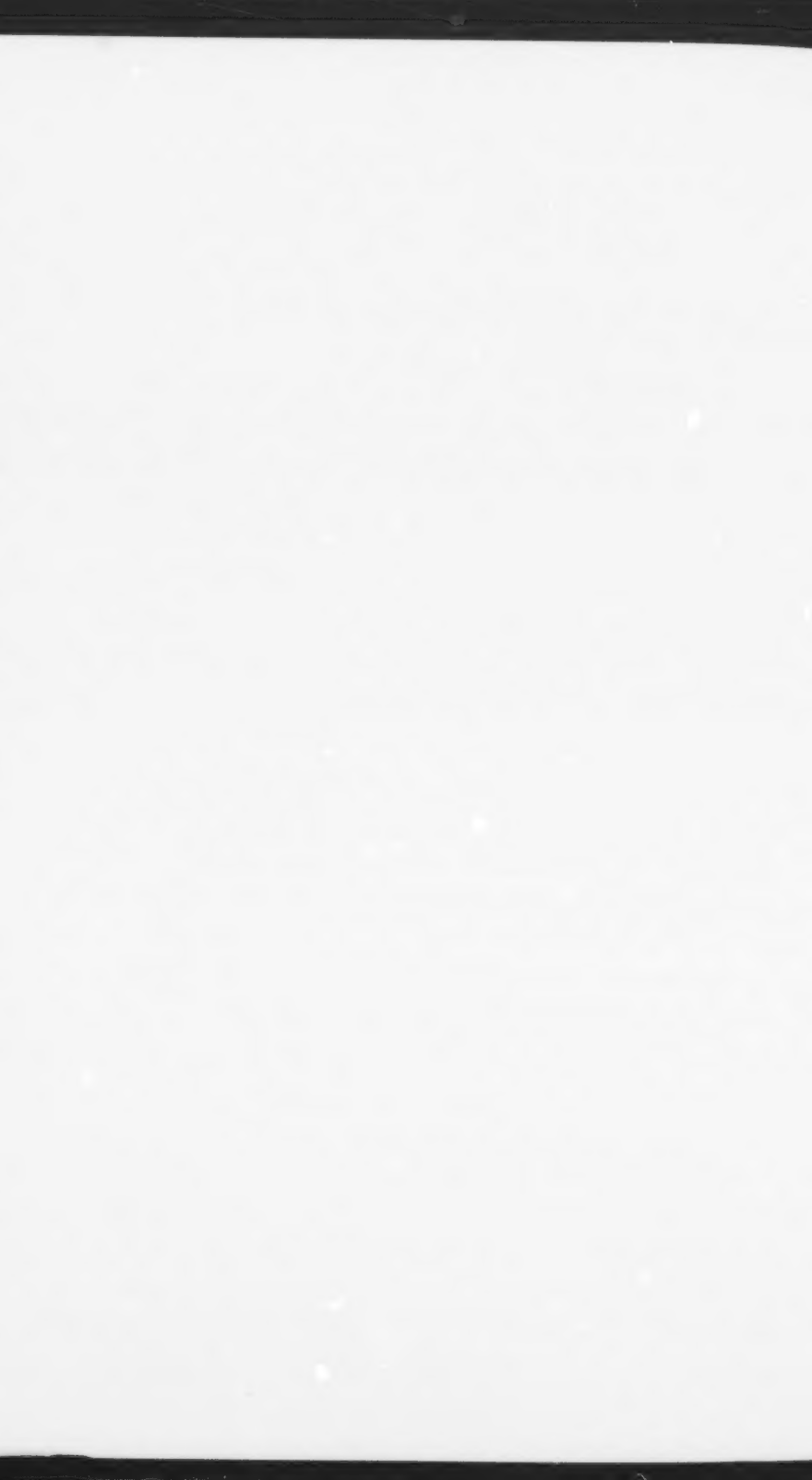
Forestry
Canada

Forêts
Canada

1988-1989



PROGRAM REVIEW



**FOREST PEST
MANAGEMENT
INSTITUTE**

1988 - 1989

PROGRAM REVIEW



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FORESTRY CANADA

Forestry Canada is the main focus for forestry matters in the federal government. It provides national leadership through the development, coordination, and implementation of federal policies and programs to enhance long-term economic, social, and environmental benefits from the forest sector for Canadians.

Forestry Canada is a decentralized organization with six regional forestry centres, two national research institutes, and seven regional sub-offices located across Canada. Headquarters is located in the national capital region, in Hull, Quebec.

In support of its mandate, Forestry Canada carries out the following activities:

- administers forest development agreements negotiated with the provinces
- undertakes and supports research, development, and technology transfer in forest management and utilization
- compiles, analyzes, and disseminates information about national and international forest resources and related matters
- monitors disease and insect pests in Canada's forests
- provides information, analyses, and policy advice on economics, industry, markets, and trade related to the forest sector
- promotes employment, education, and training opportunities in the forest sector

- promotes public awareness of all aspects of the forest sector

Forestry Canada interacts regularly with provincial and territorial governments, industry, labor, universities, conservationists, and the public through such bodies as the Canadian Council of Forest Ministers, the Forest Sector Advisory Council, the Forestry Research Advisory Council of Canada, the Canadian Forest Inventory Committee, the Canadian Committee of Forest Fire Management, the Canadian Interagency Forest Fire Centre, and regional consultative committees. Forestry Canada is also active in international forestry agencies such as the International Union of Forest Research Organizations and the Food and Agriculture Organization, as well as in technical and trade missions. ♦

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Petawawa National
Forestry Institute

FORÊTS CANADA

Forêts Canada est l'organisme principal en matière de foresterie à l'intérieur du gouvernement fédéral. Chef de file sur le plan national, il assure la préparation, la coordination et la mise en oeuvre des politiques et programmes fédéraux dans le but d'améliorer les avantages économiques, sociaux et environnementaux à long terme offerts aux Canadiens par le secteur forestier.

Forêts Canada est une organisation décentralisée: six centres de foresterie régionaux, deux Instituts de recherche nationaux ainsi que sept sous-bureaux régionaux sont répartis dans tout le Canada. La siège social est établi dans la région de la Capitale nationale, à Hull (Québec).

Pour remplir son mandat, Forêts Canada assume les tâches suivantes:

- il administre les accords de développement forestier conclus avec les provinces
- il entreprend et appuie la recherche, la mise au point et le transfert technologique dans le domaine de la gestion et de l'utilisation des forêts
- il rassemble, analyse et diffuse de l'information sur les ressources forestières nationales et internationales et les domaines connexes
- il fait des relevés des maladies et des insectes ravageurs des forêts canadiennes

- il fournit de l'information, des analyses et des conseils (quant aux politiques) concernant l'économie, l'industrie, les marchés et le commerce reliés au secteur forestier
- il favorise les occasions d'emploi et de formation universitaire et technique dans le secteur forestier
- il encourage les Canadiens à prendre conscience de tous les aspects du secteur forestier.

Forêts Canada entretient des rapports sur une base régulière avec les gouvernements provinciaux et territoriaux, l'industrie, le monde du travail, les universités, les environnementalistes et le public par l'entremise d'organismes comme le Conseil canadien des ministres des Forêts, le Conseil consultatif du secteur forestier, le Conseil consultatif de la recherche forestière du Canada, le Comité de l'inventaire des forêts du Canada, le Comité canadien de la gestion des incendies de forêt, le Centre interservices des feux de forêt du Canada et des comités consultatifs régionaux. Forêt Canada joue également un rôle actif dans des organismes internationaux de foresterie comme l'Union internationale des organisations de recherche forestière et l'Organisation pour l'alimentation et l'agriculture, de même qu'an sein de délégations de nature technique ou commerciale. ♦

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et de l'administration

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et du Labrador

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des ravageurs forestiers

DIRECTEUR
Institut forestier
national de Petawawa

DIRECTOR GENERAL'S FOREWORD

Canada is a forest nation. Forestry contributes more to our balance of international trade than agriculture, mining, fisheries and fuels combined and provides one in every 15 jobs in this country. It is important to the socio-economic well-being of all Canadians that Canada's share of the foreign market in wood and wood products be maintained or increased in the years to come. However large our forest resources may be, they are not inexhaustible and when such factors as economic accessibility, failure of natural regeneration, neglect of forest renewal on depleted productive forest lands, losses from fire, insects, diseases and competing vegetation, use of productive forest land for other purposes and other factors are taken into consideration, only a small margin exists for expanded future utilization. To help correct this situation, extensive programs of intensive forest renewal and forest management are being instituted in many areas of Canada which, to be successful, must incorporate the use of genetically superior planting stock, extensive programs of site preparation, suppression of competing vegetation, stand thinning and fertilization where required and more extensive use of forest protection practices to reduce losses from fire and from destructive insects and diseases. In short, to maximize the socio-economic benefits that can flow from our forests, we must begin to farm, not mine them. This will require the use of all silvicultural tools available to forest managers, dedication of the forestry community to the challenges presented and support of the Canadian public in these essential endeavors.

The program of the Forest Pest Management Institute addresses one important component of this broader problem—reduction of losses in forest production caused by destructive forest insects and competing vegetation to acceptable levels. These losses, which on an annual basis have been estimated at anywhere between one-half and two-thirds of the average annual harvest, cannot be tolerated and can be reduced through development and judicious use of pest control products. Development of such control products and strategies for their effective and environmentally benign use is the Forest Pest Management Institute's *raison d'être* and is in direct alignment with the overall objective of Forestry Canada: "to promote the wise management and use of Canada's forest resource for the economic, social and environmental benefit of all Canadians".

More than 50 percent of the Institute's R & D program is concerned with the development of biorational control agents for use against economically important forest insect pests. Within this part of our program, we conduct the fundamental and applied research required to develop microbial control agents—bacteria, fungi, viruses—for use against forest insect pests; we investigate the use of insect growth regulators for this same purpose; and we examine the use of insect sex pheromones or sex attractants both for monitoring the occurrence of insect pests and for their control. This biorational control agents research is supported by fundamental research in insect tissue culture, immunochemistry and biological systems analysis, which are essential for the identification of control agents, elucidation of their precise modes of action, development of improved methods for their mass

production, and for determination of optimal strategies for their effective use.

A large part of the Institute's program is concerned with the development of chemical insecticides and herbicides for use against destructive forest insect pests and competing vegetation. Until biorational control agents can be developed to their full potential, we will have to rely heavily on these materials as our first line of defense in forestry and, regardless of what developments occur on the biorational side, it is almost certain that we will always have to depend on chemical pesticides at least to some extent. Research in this area includes the toxicology and screening of new and/or improved insecticides and herbicides for forestry use, determination of their efficacy under field conditions and development of improved methods for using them. To optimize the effectiveness of both chemical and biorational control agents, methods must be developed to deliver them directly to the target area in the precise amounts required to meet protection requirements and to minimize undesirable effects on other components of the forest ecosystem. The Institute is, therefore, significantly involved in application technology research including the effects of formulation properties on spray cloud emission and behavior, and the effect of meteorological and other factors on spray cloud behavior from emission to canopy penetration and impaction.

The responsible use of pest control products demands that their use impose minimal risk to the environment or to human health. While the effects on human health lie outside the mandate of the Forest Pest Management Institute and are evaluated by appropriate federal and

provincial health agencies, the Institute is heavily involved in research on the environmental impact and chemical accountability of pesticides. This research is required to determine the effects of pesticides on non-target organisms in the forest environment and the persistence, dynamic cycling and ultimate fate of these products and their metabolites in the forest ecosystem.

All of these R & D thrusts are supported by a Complementary Services Project that provides electron microscopy services and the insect, plant, and pathogen production services required to facilitate research in the R & D program.

This Program Review booklet is designed to acquaint the reader with the Forest Pest Management Institute, and its mandate and its program. Data generated within the Institute's R & D program are essential for the development of new and/or improved pest control products for forestry use and for development of strategies for their operational use that will optimize effectiveness and minimize adverse environmental impact. In addition, Institute research provides much of the data upon which the registration status of pest control products for forestry use is determined under the Pest Control Products Act and upon which effective yet environmentally benign use patterns are developed and promulgated. ♦



G.W. Green

Director General

1 October, 1989

MICROBIAL CONTROL AGENTS

A wide variety of naturally occurring insect pathogens, including bacteria, viruses, and fungi can have adverse effects on the survival and reproduction of forest insect pests. To increase the number of options available to the forest manager for control of economically important insect pests, biological control research at the Institute is aimed at identifying those insect pathogens that are promising candidates for insect population regulation and identifying the conditions under which their full potential can be exploited. When these conditions have been identified, use strategies can be developed for these pathogens, either by themselves or in concert with other control agents, such as chemicals.

Institute research into biological control presently concentrates on three main areas; the identification of insect-specific pathogens for pest control, the elucidation of the conditions under which these organisms exert their effect on naturally occurring populations, and the development of strategies for their effective use. These projects investigate naturally occurring host-pathogen interactions, develop data necessary to support petitions for registration of candidate pathogens, and improve application strategies for registered agents. The Institute research program also involves the genetic manipulation of bacteria and viruses to develop more virulent strains, and microbial insecticides with improved characteristics. ♦

FP-10 BACTERIAL PATHOGENS

PROJECT STAFF: K. van Frankenhuyzen (*Project Leader*),
Vacant (*Study Leader*), C. Budau, R. Milne, C. Nystrom, T. Wright

OBJECTIVES: To enhance the effectiveness of *Bacillus thuringiensis* and related bacterial pathogens for use in the control of forest insects in Canada.

ACHIEVEMENTS: Dr. P.G. Fast retired in October 1987, but was retained on a part-time basis during 1988-89 to provide scientific coordination of the BIOCIDE network. Work continued on production of purified toxin fragments and reactive sites within the protoxin sequence, and bioassays of cloned gene products and toxic fragments were conducted. The influence of temperature on budworm acquiring a lethal dose of *B.t.* was determined; the relationship between ingested dose, feeding inhibition, recovery and mortality was established and field trials of ULV applications of *B.t.* against gypsy moth were continued.

PROJECTIONS: During 1989-90, bioassay support for BIOCIDE will continue. Studies of enzyme cleavage of crystal protein using purified gut enzymes from spruce budworm will be initiated. Work on the influence of temperature on dose acquisition will be extended to lower temperatures, and attempts will be made to confirm relationships between dose acquisition and efficacy through cooperative field trials. Field trials of high potency UULV applications against gypsy moth will continue. ♦

FP-11 FUNGAL PATHOGENS

PROJECT STAFF: D. Tyrrell (*Project Leader*),

K. Humphries, M. Welton

OBJECTIVES: To develop methods and procedures for the use of entomogenous fungi in the management of forest insects in Canada.

ACHIEVEMENTS: During 1988-89, the FPMI-FCOR (Forestry Canada - Ontario Region) collaborative study on spruce budworm survivorship continued, and assistance was provided in the identification of field-collected fungi. Greenhouse and single tree studies with dried *Entomophaga aulicae* preparations were completed and published. Dried mycelial preparations of *E. crustosa* were prepared, but no success was achieved in maintaining the viability of mycelia. In-depth studies of the pathology of *E. aulicae* were continued and work on the identification of fungi attacking alfalfa weevils in Ontario was completed and published.

PROJECTIONS: During 1989-90, the spruce budworm survivorship study with FCOR will continue. Pathological studies with *E. aulicae* will be extended. Laboratory and field work with *Beauveria bassiana* against lymantrids and other insects will be initiated. ♦

FP-13 VIRAL PATHOGENS

PROJECT STAFF: J.C. Cunningham (*Project Leader*),
B.M. Arif (*Study Leader*), W.J. Kaupp (*Study Leader*), K.W. Brown,
P.M. Ebling, P.B. Jamieson (*Research Associate*), H. Lauzon

OBJECTIVES: To develop viruses for effective and environmentally acceptable use in the population regulation of important forest insect pests.

ACHIEVEMENTS: During 1988-89, Disparvirus applied as a double application of 1.25×10^{12} PIB/ha against gypsy moth produced outstanding results. Processing of sufficient Virtuss (Douglas-fir tussock moth) to treat 1,400 ha for the B.C. Forest Service neared completion; Lecontvirus was distributed to provincial clients in Ontario. A number of viruses were bioassayed against the black army cutworm. Techniques were developed for quantitative sampling of naturally occurring gypsy moth NPV on leaf surfaces and LD₅₀s of wild-type NPV were completed for fourth, fifth and sixth instar budworm larvae. Eight strains of spruce budworm NPV were isolated and assayed for infectivity in eastern spruce budworm larvae with no significant differences in infectivity occurring. Cooperative work with members of NRC's Biotechnology Research Institute to sequence genes of spruce budworm NPV was initiated; RNA from virus-infected cells was isolated and a start was made on establishing a DNA library. Experimentation to produce recombinants between cabbage looper and spruce budworm NPVs was continued.

PROJECTIONS: During 1989-90, field trials with Disparvirus, will continue at lower dosages and volumes to determine optimal field application rates. Virtuss, labelled and bioassayed, will be provided to the B.C. Forest Service to complete cooperative undertakings, and shelf-life studies on Sertifervirus will be completed. The spread and environmental fate of gypsy moth NPV will be studied; work on virus-host interactions with spruce budworm will continue and NPV of the Bruce spanworm will be collected and characterized. A biotechnology research network on insect pathogens (MICROBIONET) will be initiated; sequencing of the polyhedrosis gene of spruce budworm NPV will be undertaken and homologous regions and recombination sites on spruce budworm NPVs will be located. A complementary DNA library from spruce budworm messenger RNA will be completed. ♦

BIOLOGICAL INTERACTIONS

In a research program as broad as that of the Institute there is an essential requirement for research into the biological effects of a variety of insect pest control methods, and for systems to study modes of action and identification. To conduct such research, and to develop the information required to successfully carry out other Institute projects, three areas are investigated. These are: Tissue Culture, for the study of insect pathogens *in vitro*; Immunochemistry, for identification and characterization of pathogens and their constituents; and Biological Systems Analysis, for the development and application of methods in experimental design, statistical analysis, and modelling, which contribute to the solution of complex problems in forest pest management. In addition to significant individual contributions, these projects have strong ties across the Institute's research program. ♦

FP-20 INSECT PATHOGENS *IN VITRO*

PROJECT STAFF: S.S. Sohi (*Project Leader*), G. Caputo, B. Cook

OBJECTIVES: To develop and apply insect tissue culture methodology for the *in vitro* investigation of insect pathogens with a view to enhancing their effectiveness in the management of forest insect pests.

ACHIEVEMENTS: During 1988-89, a cell culture bioassay (Lawn Assay) was developed and perfected for *B.t.* delta-endotoxin using the CF-1 cell line. Work on the virus-specific polypeptide synthesis of spruce budworm NPV in CF-70 cells was completed in cooperation with B. Arif and P. Jamieson; the infectivity of spruce budworm NPV in CF-70 cells was studied further as was electron microscopy of C/NPV replication in this cell line.

PROJECTIONS: During 1989-90, the kinetics of C/NPV replications in CF-70 cells will be studied; the effect of ecdysterone and related compounds on insect cell cultures will be investigated with A. Retnakaran; new primary cell cultures from spruce budworm ovarian tissues will be initiated; a start will be made in adapting spruce budworm cell cultures to fetal bovine serum-free culture media. In addition, the possibilities of establishing a cooperative cell culture research network as a component of MICROBIONET will be investigated. ♦

FP-22 IMMUNOCHEMISTRY

PROJECT STAFF: A. Pang (*Project Leader*), B. Mathieson

OBJECTIVES: To develop and apply immunochemical techniques to the identification, characterization and genetic manipulation of insect pathogens, thus improving the quality of the biological pest control agents.

ACHIEVEMENTS: During 1988-89, more than 40 monoclonal antibodies to the HD-1 toxin were produced and a number of these were cloned, recloned and tested to determine whether or not they could differentiate toxin from the products produced by cooperators. Preliminary work suggests that CF-1 cell membrane components are good candidates for *B.t.* toxin acceptors. Identification of the toxic regions of the *B.t.* crystal toxins was confirmed. The monoclonal antibodies to spruce budworm NPV were produced; most of these react only with the polyhedral protein. More work is required in this area.

PROJECTIONS: During 1989-90, the biochemical structure relationship between the three HD-1 *B.t.* toxin gene products and other *B.t.* toxins will be studied; continued attempts will be made to identify *B.t.* toxin receptors with antibodies as well attempts to identify the viral proteins responsible for host specificity and virulence in spruce budworm NPV. ♦

FP-23 BIOLOGICAL SYSTEMS ANALYSIS

PROJECT STAFF: R.A. Fleming (*Project Leader*), T. Burns

OBJECTIVES: To apply a systems analysis approach, as appropriate, in research contributing to the better management of forest pests.

ACHIEVEMENTS: During 1988-89, interlab comparisons of songbird cholinesterase assessment were conducted and showed poor interlaboratory correlation; large scale spruce budworm simulation models were tested and results reported; a prototype model for spruce budworm feeding on diet was completed; development of a jack pine cone crop sampling plan was initiated as was development of a model for white pine weevil emergence. Modelling work on spruce budmoths and on spruce budworm impact continued and modelling of germination of the fungal pathogens, *E. radicans* and *E. crustosa* was completed.

PROJECTIONS: Work in 1989-90 will continue on budworm feeding models and foliage phenology models; development of a jack pine cone crop sampling plan will continue, as will modelling of white pine weevil emergence. Statistical analyses for the spruce budmoth impact model will be completed and an experimental design for improved use strategies for glyphosate will be completed. ♦

PHYSIOLOGICAL MECHANISMS

A forest insect pest grows and develops through a complex and interrelated series of steps, including larval and pupal stages, mating, and reproduction. As knowledge of the physiological mechanisms associated with such development becomes more complete, so do the opportunities to identify critical stages that can be manipulated to control economically important insect pests. The Institute program in this area includes research into the physiological mechanisms associated with normal growth and development, and the physiological and behavioral aspects of insect mating and reproductive behavior. The possibility of manipulating these mechanisms, through chemical or other means, to the detriment of insect survival within a generation, and from one generation to the next, arises from this research. Studies in these areas lead directly to the screening of candidate insect growth regulators and pheromones. As well as having potential as insect control agents, pheromones can play a vital role in monitoring insect populations and predicting outbreaks. ♦

FP-30 PHEROMONES

PROJECT STAFF: G.G. Grant (*Project Leader*),
D. Frech, D. Lombardo

OBJECTIVES: To advance the use of sex pheromones and related behavior-modifying chemicals for the management and monitoring of forest insect pests by providing the requisite knowledge on their chemical identification, behavioral function, and practical application.

ACHIEVEMENTS: During 1988-89, the identified pheromone components of the fir coneworm were field evaluated in Ontario and Michigan; the main pheromone component for the oak olethreutid leaf roller was confirmed by field tests in N.S. and lures for it were supplied to FIDS Maritimes; field testing of pheromone components for *Eucosoma* coneworm spp. and western *Dioryctria* spp. were continued and the identified pheromone components of the large aspen tortrix were evaluated in field tests. Lures for the spruce seed moth were supplied to N.B. DURE to initiate a trapping survey of seed orchards; lures were supplied to FIDS Ontario Region and Maritimes for monitoring programs for the oak leaf shredder and to the city of Edmonton to survey for the spruce budmoth.

PROJECTIONS: During 1989-90, work will continue to identify the pheromone components of the fir coneworm and field testing will take place in Ontario and New Brunswick; lures for western *Dioryctria* spp. will be tested in B.C. to determine what species are there; GC/EAG analyses of the oak olethreutid leaf roller pheromone will be

completed; work will continue with pheromone components of *Eucosoma* coneworms and attempts will be made to identify minor (but important) pheromone components for *Orgyia leucostigma*. Field work to identify pheromone components of the large aspen tortrix will continue. Work to improve the lure specificity for the spruce seed moth and the oak leaf shredder and to relate pheromone trap catches to population density of the gypsy moth will be initiated. ♦

FP-31 INSECT GROWTH REGULATORS

PROJECT STAFF: A. Retnakaran (*Project Leader*),

L. Smith, W. Tomkins

OBJECTIVES: To evaluate and develop the rational use of Insect Growth Regulators for the control of insect pests of Canadian forests by investigating the physiological, morphological and biochemical effects of various IGRs that adversely interfere with metamorphosis in forest insect pests as well as model insects.

ACHIEVEMENTS: During 1988-89, further studies on white pine weevil biology and activity were conducted to develop an emergence model; Dimilin was field tested against the weevil in Ontario and Quebec with promising results; work continued on the use of juvenile hormone to increase virus production in spruce budworms; two powerful ecdysone agonists were tested against an array of forest insect pests and a new benzoyl urea IGR was compared with Dimilin and chlorofluazuron against several insect pests. Aerial field trials of Dimilin against the hemlock looper and spruce budmoths were

conducted and juvenile hormone analogs were tested in Newfoundland against the balsam woolly aphid.

PROJECTIONS: During 1989-90, studies of white pine weevil biology and behavior will continue to produce an emergence predictive model for control purposes; field tests of Dimilin against the white pine weevil will continue to confirm efficacy and application strategies; the juvenile hormone/NPV interaction in the spruce budworm will be investigated further; the effect of benzoyl ureas in chitin biosynthesis will be studied. New IGR's and hormone analogs will be tested as they appear. ♦

PESTICIDE TOXICOLOGY & EFFICACY

A wide variety of forest insect pests inflict severe damage on Canadian forests each year. The best estimates currently available suggest that the average loss in wood volume caused by the activities of our major forest insect pests approaches or exceeds some 63 million m³ per annum. Competition from undesirable tree species, grasses, and weeds often impedes the establishment, survival, and growth of desired crop species by as much as 50%. Losses of this dimension cannot be tolerated if Canada is to meet wood production goals accepted by the Canadian Council of Resource and Environment Ministers for the year 2000, or if we are to maintain Canada's share of the foreign market in wood and wood products. Such losses can be prevented, or at least reduced substantially, by the judicious use of pesticides. Most insecticides and herbicides are developed by the pesticide industry first for the agricultural use market, which is very large and stable compared to the forestry use market. Before such materials can be registered and used for forestry purposes, their efficacy against forest insect pests and unwanted vegetation must be determined and dosage rates that will balance efficacy and acceptable environmental impact must be established.

To help ensure that forest managers have a range of effective insecticide and herbicide alternatives available for their use, the Institute maintains a continuing program that screens new products and modified formulations of existing ones to determine toxicity against a range of target pests. Those pesticides that appear to have

potential for forestry use are tested in a series of field efficacy trials to establish actual use potential, required dosage rates, and use patterns after full consideration has been given to the biology of target pests and host species. The data generated by this program become essential components of the data package that is eventually submitted in support of registration of these pesticides for forestry use under the Pest Control Products Act. They also form the basis of control recommendations to forest managers. ♦

FP-50 INSECTICIDE TOXICOLOGY

PROJECT STAFF: B.V. Helson (*Project Leader*),

D. Comba, J. McFarlane

OBJECTIVES: To determine the toxicological properties of insecticides and other chemicals on forest pests and selected non-target organisms.

ACHIEVEMENTS: During 1988-89, research on the toxicity of encapsulated permethrin to spruce budworm and mosquito larvae continued; the contact and residual toxicities of two ecdysone agonists, RH-5849 and RH-5992 against spruce budworm was investigated; the toxicity of alpha-terthienyl, a natural, phototoxic plant compound to budworms was investigated at various UV light levels; studies on the nature of the residual toxicity of Zectran continued and work on the effects of temperature on the toxicity of fenitrothion and aminocarb was completed. Cooperative field trials with the Québec Ministry of Energy and Resources confirmed the effectiveness of permethrin against the spruce budmoth. A number of insecticides were compared in the laboratory for toxicity to the larval stages of the eastern hemlock looper. Work continued on comparative toxicities of various insecticides against *Hylobius congener*, gypsy moth, and cone beetles.

PROJECTIONS: During 1989-90, research with microencapsulated permethrin will be completed; investigation of the toxicity of RH-5992 will continue; work on the toxicity of alpha-terthienyl will be completed; work will be initiated on the spectrum of activity of promising plant-derived substances; studies of the residual toxicity of

Zectran and its metabolites will be completed; studies on the effect of temperature on the toxicity of insecticides and the effects of weather on residual toxicity will be terminated. Cooperative studies on permethrin against the spruce budmoth and various insecticides against the hemlock looper, *Hylobius congener*, gypsy moth, and cone beetles will be continued. Studies on feeding preference of the forest tent caterpillar and gypsy moth for red maple will be initiated. Buffer requirements for aerially applied permethrin will be determined. ♦

FP-51 INSECTICIDE FIELD EFFICACY

PROJECT STAFF: B.L. Cadogan (*Project Leader*),
R. Scharback, B. Zylstra

OBJECTIVES: To develop suitable methodology and data to assess the efficacy of insecticides, formulations and pest control strategies as required for the management of forest insect pests.

ACHIEVEMENTS: During 1988-89, Futura XLV, Futura HP, Dipel 8AF, Dipel 12L and Dipel 16L were tested against spruce budworms in northwestern Ontario. A planned field trial with Condor, a manipulated *B.t.* preparation was not tested as planned because a federal research permit was not granted.

PROJECTIONS: During 1989-90, the efficacy of high potency Futura and Dipel *B.t.* formulations, Condor and a new experimental *B.t.* formulation from CIL will be determined through field trials. Cooperative work with FP-10-2 will be initiated to develop a sample assessment technique for determining the need to respray with *B.t.*;

research on factors influencing the efficacy of applied pest control products will be initiated and the field characterization of rotary atomizers for insecticide and herbicide applications will continue. ♦

FP-52 PLANTATION PEST MANAGEMENT

PROJECT STAFF: J. Turgeon (*Project Leader*),
P. de Groot (*Study Leader*), N. Nelson, A. Obarymskyj

OBJECTIVES: To develop integrated pest management systems for insect pests of coniferous plantations grown for seed and lumber production.

ACHIEVEMENTS: During 1988-89, work on the identification of families of white spruce less susceptible to attack by the spruce budmoth was completed as was field testing to establish a pheromone-based monitoring system for this pest. Field studies were continued on mortality factors for black spruce, white spruce and tamarack cones; the biology of the spruce cone maggot in black spruce was investigated; a life-table for white spruce cones was initiated; a study of clonal variations in susceptibility to damage by cone and seed insects in black and white spruce seed orchards was initiated and studies on sampling methods for the spruce cone maggot and cone maggots on tamarack were continued. Studies of the biosystematics of *Conophthorus* were completed; a three-year study of mortality factors of jack pine cones was prepared for publication; and, investigation of clonal variability in susceptibility of jack pine to cone and seed insects was initiated.

PROJECTIONS: During 1989-90, data analysis on a pheromone-based monitoring system for the spruce budmoth will be completed; field studies on mortality factors of black spruce cones will be continued, but those for white spruce cones and tamarack cones will be deferred. Development of sampling methods for cone and seed insects will continue and studies on the seed-destroying capacity of cone maggots on black spruce cones will be initiated. Work on jack pine cone distribution will be published; the jack pine cone-life table analysis will be completed; studies on cone beetle pheromones will be continued, as will a laboratory study on the toxicity of permethrin to cone beetles. ♦

FP-53 HERBICIDE PHYSIOLOGY

PROJECT STAFF: R. Prasad (*Project Leader*), J. Studens

OBJECTIVES: To screen herbicides and other weed control products for potential field testing and to develop suitable methodology and data on physiological mechanisms of herbicide action to predict efficacy and crop tolerance of herbicides, formulation adjuvants and improved use strategies under laboratory, greenhouse and/or microplot field conditions.

ACHIEVEMENTS: During 1988-89, the Project Leader for this project was relocated to Forestry Canada, Pacific and Yukon Region. As a consequence, no new work was initiated in the project and emphasis was placed on completion of small plot field trials to determine the optimal droplet size for Vision and in completing reports

to cooperators on the effects of various adjuvants on the efficacy and crop tolerance of Vision and Velpar.

PROJECTIONS: Staffing action for the Project Leader position was initiated in 1988-89, and it is expected that the successful applicant will be on staff early in 1989-90. At that time, the project will receive an in-depth review and its direction for future years will be determined. ♦

FP-54 HERBICIDE FIELD EFFICACY

PROJECT STAFF: P. Reynolds (*Project Leader*), D. Pitt

OBJECTIVES: To develop suitable methodology and data to assess the efficacy and crop tolerance of new herbicides, formulations and vegetation control strategies as required for the management of forest weed species under practical field conditions in Canada and to develop new and improved use strategies for forestry herbicides that provide maximum crop tree growth response with minimal environmental impact.

ACHIEVEMENTS: During 1988-89, the proceedings of the cooperative Carnation Creek Herbicide Trials were published; Ontario and New Brunswick studies with Pronone were completed; New Brunswick Ally/Oust trials were completed; second season herbicide efficacy and first season crop tolerance data for the New Brunswick Velpar ULW study was collected; fourth year white spruce growth data for the New Brunswick Velpar L trial was gathered as was third-year black spruce growth data for several New Brunswick herbicide site

preparation treatments. Studies on the effect of fireweed on crop tree health and growth were continued in New Brunswick and an improved use trial was carried out with Vision.

PROJECTIONS: In 1989-90, data collection related to the N.B. Velpar ULW study will continue; studies on white and black spruce growth following Velpar L treatment and Pronone, Velpar L, Ally and Oust treatments, respectively, will continue; the N.B. fireweed study will continue; one-year post-spray vegetation assessments for the N.B. Vision improved use trial will be made; and a N.B. comparative brush herbicide trial (Vision, Touchdown, Garlon 4, Ally and Arsenal) will be initiated. ♦

APPLICATION TECHNOLOGY

The ultimate goal in the operational application of any pesticide by whatever application method is to assure that only the essential required amount of the pesticide is emitted, and that as much of the emitted material as possible reaches the intended target in a form that optimizes its effectiveness against the target pest. If this goal is achieved, drift beyond the target area is minimized and the effectiveness of the pesticide against its intended target is maximized.

A great number of factors affect achievement of this ultimate goal. For example, the physicochemical characteristics of liquid sprays affect the production size, and evaporation of the spray droplets. Dispersal system design, nozzle type, pressure, flow rate of the emission system, and speed of the vehicle carrying the emission system also influence the droplet pattern produced. Meteorological conditions during application affect the movement of the spray cloud, evaporation of the droplets, and penetration into and impaction on the forest canopy.

A thorough understanding of all of these factors and their interactions is essential if pesticides are to be applied in the most economical, efficacious, and environmentally acceptable manner. Therefore, research into all of these areas is an important aspect of the Institute's overall R & D program. ♦

FP-61 PESTICIDE FORMULATIONS

PROJECT STAFF: A. Sundaram (*Project Leader*), J. Leung

OBJECTIVES: To assess and/or modify the physicochemical properties and behavior of pesticide formulations to improve upon stability, handling, dispersal and deposition characteristics required to maximize efficacy and to minimize environmental impact.

ACHIEVEMENTS: During 1988-89, laboratory tests of rainfastness of *B.t.* in a canola oil carrier were carried out. Although this carrier improved rainfastness on balsam fir foliage, suspensibility was adversely affected. Field tests in cooperation with NeFC indicated that two Day-Glo fluorescent dyes used improved deposit assessment (Erio Acid Red and Automate 5) of oil-based and aqueous tank mixes. Tests were conducted with a range of adjuvants to improve the rainfastness of Vision and techniques were developed to assess the spreading and wetting characteristics of herbicide formulations.

PROJECTIONS: During 1989-90, methodology development for assessing the physicochemical properties and behavior of pesticide formulations and for defining degree of spreading and adhesion on target and non-target surfaces will continue. The rainfastness of six Dipel (*B.t.*) formulations will be investigated in the laboratory and laboratory, and field trials will be conducted to determine the effects of adjuvants on the rainfastness of glyphosate. ♦

FP-62 APPLICATION TECHNOLOGY FOR FORESTRY PESTICIDES

PROJECT STAFF: N. Payne (*Project Leader*), D. Curry

OBJECTIVES: To advance knowledge of spray cloud formation, dispersal and deposition, with a view to improving pesticide-use strategies by increasing efficacy, reducing off-target deposit and the cost of forestry pesticide applications.

ACHIEVEMENTS: During 1988-89, participation in a collaborative field trial to measure phytotoxicity of sub-lethal glyphosate deposits continued; precise assessments of the meteorological conditions in the boundary layer above a jack pine stand during periods near dawn and dusk were conducted; a rainfall simulator for an eastern Canada climate was designed, constructed and tested; and analyses of spray cloud dispersal from low volume herbicide applications were completed.

PROJECTIONS: During 1989-90, the project will participate in a collaborative field trial to verify buffers for permethrin aerial applications; design and execute field experiments to assess foliar insecticide deposits under different meteorological conditions; participate in a collaborative SERG field trial to measure on- and off-target deposit from glyphosate use strategies; continue mathematical modelling to determine buffers for low volume aerial applications of glyphosate and complete testing and refinement of rainfall simulator constructed last year. ♦

ENVIRONMENTAL CONCERNS

A significant portion of the Institute's technical expertise and resources are directed toward determination of the effect of insecticides and herbicides (chemical and biological) on non-target avian, terrestrial, and aquatic organisms in the forest environment and to elucidation of the occurrence and fate of these materials, and their breakdown products in foliage, soil, litter, water, and bottom sediment after application.

Before a pesticide can be used in Canada it must be registered under the Pest Control Products Act, which is administered by Agriculture Canada. Under the terms of this Act, a pesticide must be proved effective and its use must not have a significant, adverse impact on environmental quality or on human health. To have such materials registered for forestry use in Canada and to develop the most appropriate use patterns for them, it is essential that we have an adequate understanding of their impact on non-target, naturally occurring species in the forest environment, and of their persistence, mobility, and ultimate fate in that environment. While such knowledge is essential for registration purposes, it is just as essential in adequately addressing public concerns relating to the use of these forest management tools. ♦

FP-70 ENVIRONMENTAL IMPACT

PROJECT STAFF: S. Holmes (*Project Leader*),
K. Barber, D. Kreutzweiser, R. Millikin (*Study Leaders*),
S. Capell, vacant technician

OBJECTIVES: To develop necessary experimental methods and carry out field and laboratory studies to determine potential environmental impacts of forest pesticides on forest ecosystems and to develop and recommend pest management strategies and pesticide use patterns to minimize these impacts under operational conditions.

ACHIEVEMENTS: During 1988-89, a study to investigate the effect of triclopyr on yellow finch behavior was initiated; 1 year post-treatment (permethrin) effects on brook trout populations and aquatic invertebrates were obtained; data collection for long-term songbird population trends in the Icewater Creek study continued; studies of exposure-toxicity relationships for pollinating insects continued, and a study was initiated on the impact of *B.t.* on non-target lepidoptera.

PROJECTIONS: During 1989-90, laboratory studies on the effect of pesticides on cholinesterase inhibitors and behavior in songbirds will be resumed; studies on the effect of selected herbicides on forest songbirds will be continued; brook trout population monitoring and invertebrate monitoring at the Icewater Creek study area will continue as a prelude to planned permethrin treatment in 1990; a bioassay procedure using an artificial stream to test susceptibility of aquatic

invertebrates to pesticides will be developed; the effects of *B.t.* and fenitrothion on songbird reproduction and population dynamics will be compared and work will continue on the impact of *B.t.* on non-target lepidoptera. ♦

FP-71 INSECTICIDE CHEMICAL ACCOUNTABILITY

PROJECT STAFF: K.M.S. Sundaram (*Project Leader*),
J. Broks, R. Nott

OBJECTIVES: To develop analytical methodology and to determine the environmental distribution, degradation, dynamics, persistence, toxicity and metabolic fate of forest insect control products to help in the evaluation of their benefits and potential risks to the ecosystem.

ACHIEVEMENTS: During 1988-89, studies were conducted on the uptake, translocation and fate of acephate and methamidophos in black spruce and its effect on the black spruce beetle; the toxicity of mexacarbate and its metabolites to budworm was determined; a GLC method for assessing acephate and its major metabolite was developed and a method for the rapid determination of permethrin residues in various stream matrices were developed.

PROJECTIONS: During 1989-90, analytic support will be provided for buffer zone evaluation of permethrin; field studies of the mobility, persistence and fate of diflubenzuron in two forest soil types will be initiated; studies of the residual toxicity of mexacarbate and its

metabolites in conifer foliage will be continued; cooperative research with Ace Cep implementation techniques on black spruce beetles with NeFC will continue and the ability of immunochemical techniques for the quantification of pesticide residues will be investigated. ♦

FP-72 HERBICIDE CHEMICAL ACCOUNTABILITY

PROJECT STAFF: D. Thompson (*Project Leader*),
L. MacDonald, B. Staznik

OBJECTIVES: To develop and validate analytical methods for the quantification of herbicide residues in environmental quantification of herbicide residues in environmental matrices and to implement such methods in laboratory and field research experiments designed to elucidate the environmental fate and persistence of herbicides in Canadian forest ecosystems.

ACHIEVEMENTS: During 1988-89, analytical methods were developed and validated for the determination of glyphosate residues in a variety of forestry matrices; a capillary GLC-ECD method for determination of metsulfuron methyl residues in environmental substrates is under development; research on the Carnation Creek project was completed; Dora Creek triclopyr residue analyses were completed; laboratory leaching and persistence studies with metsulfuron were completed; field studies of soil persistence and leaching and the fate and impact of metsulfuron methyl in a lake ecosystem were initiated. Glyphosate deposits on artificial deposit and

drift collectors were quantified as part of a glyphosate improved use study undertaken by FP-54.

PROJECTIONS: During 1989-90, modifications to improve the HPLC-VIS method for determination of glyphosate residues will be introduced; a triclopyr aquatic fate and impact study will be initiated in cooperation with FP-70 at the Icewater Creek study area and, with the same project, laboratory studies on the impact of triclopyr on forest songbirds will commence. Field studies with metsulfuron will continue and cooperative research will be undertaken with FP-54 in the comparative N.B. brush herbicide trials. ♦

COMPLEMENTARY SERVICES

A wide range of services that can produce the insect species, pathogens, and plant material required for laboratory research and field testing are essential to the research being conducted at the Institute. Insects provided by the Insect Production section are used in a variety of laboratory experiment and testing programs, for production of insect viruses for field testing and operational use, and for distribution to a number of cooperators within and outside of Forestry Canada. The Pathogen Production section produces viruses for testing, and indeed, is presently the sole source for the two insect viruses registered for forestry use in Canada. The Plant Production section grows a variety of plant species required for insect food and for screening of biological and chemical insecticides, as well as representative species for use in screening of herbicides with potential for use in Canadian forestry.

In addition to the areas mentioned above, FPMI has other essential complimentary services relating to diagnosis of insect diseases, electron microscopy, aircraft services for provision of spray aircraft and application equipment for field research projects, technical services for maintenance, design, and construction of specialized scientific equipment, microphotography services to program elements and also chemical analytical services relating to FPMI's GC/MS. ♦

FP-40-1 INSECT PRODUCTION

PROJECT STAFF: B. McCron (*Study Leader*),
K. Barratt, S. Charrette, L. Harwood, S. White, H. Wigney

OBJECTIVES: To develop and carry out insect rearing methods that will provide the numbers and varieties of insects required by Institute research projects, and to supply other research cooperators as Institute priorities and resources permit.

ACHIEVEMENTS: During 1988-89, insect production continued at a high level. Nineteen (19) insect species were reared; 6 million larvae were produced, and over 2 million budworm larvae were provided to outside agencies. Techniques were implemented to reduce fungal contamination of artificial diet; a reliable method of rearing the black army cutworm was developed; a rearing culture of the spruce budmoth was established and guidelines for handling spruce budworm larvae were provided to cooperators.

PROJECTIONS: During 1989-90, demands for insect stock by Institute researchers and cooperators will continue to be met; improvements will continue to be made in rearing techniques and, if funds are available, a manual on insect rearing methods developed at FPMI will be produced under contract. ♦

FP-40-2 PATHOGEN PRODUCTION

PROJECT STAFF: B.E. Cunningham (*Study Leader*)

OBJECTIVES: To develop, adapt, modify and apply sophisticated methodology to mass production of viruses and protozoa for subsequent use in the regulation of forest insect pests.

ACHIEVEMENTS: During 1988-89, 8,400 g of Disparvirus containing 10^{10} PIB/g was produced for field trials. Processing of Virtuss to meet supply commitments with the B.C. Ministry of Forests for use against outbreaks of the Douglas fir tussock moth and for Nova Scotia Lands & Forests for use against the whitemarked tussock moth were continued. Lecontvirus was provided to OMNR staff and to Domtar Forest Products staff for use against the redheaded pine sawfly.

PROJECTIONS: During 1989-90, existing stocks of Virtuss will be processed, packaged and delivered to the B.C. Ministry of Forests; Disparvirus will be produced for field trials and stocks of Sertifervirus and Lecontvirus will be augmented for use by clients as required. ♦

FP-40-3 DISEASE DIAGNOSIS

PROJECT STAFF: G. Wilson (*Study Leader*), vacant technician

OBJECTIVES: To identify and determine the effects of pathogens from submitted or field-collected specimens.

ACHIEVEMENTS: During 1988-89, this study was amalgamated with FP-40-2. Insect rearing staff were trained to identify pathogens

in insect rearing stock; pathogen collections were diagnosed for the Ontario Ministry of Natural Resources and for Agriculture Canada, and starter cultures of various microsporidia were maintained.

PROJECTIONS: Reporting on this activity will henceforth appear under FP 40-2 (Pathogen Production). Pathogens found in samples of forest insect pests submitted by cooperators will be diagnosed and stock cultures of microsporidia will be maintained. ♦

FP-40-4 ELECTRON MICROSCOPY

PROJECT STAFF: A. MacDonald (*Study Leader*), A. Brownwright

OBJECTIVES: To provide electron microscopy services to a number of Institute projects including sample preparation, processing, sectioning and technical interpretation.

ACHIEVEMENTS: During 1988-89, a new Jeol Jem 1200 Ex II transmission electron microscope was installed; the experimental phase of an investigation into the effect of EPV on budworm oenocytes and cuticle development was completed; an investigation of the mode of action of the insect growth regulating chemical RH 5849 was continued and ultrastructural evidence from neurosecretory regions of the brain and various glands of the spruce budworm was obtained. Lectin-gold cytochemistry techniques were used to study chitin synthesis and cell wall deposition in *Entomophaga aulicae*.

PROJECTIONS: During 1989-90, investigations noted above, will be continued and electron microscopy services will continue to be provided to FPMI staff. ♦

FP-40-5 PLANT PRODUCTION

PROJECT STAFF: D. Buckley (*Study Leader*), S. MacLeod

OBJECTIVES: To adapt, develop, extend and apply sophisticated methodology in plant production and animal rearing that will provide, as required, material for use in the Institute's research programs.

ACHIEVEMENTS: During 1988-89, all demands for greenhouse service and greenhouse research space required by FPMI staff were met; changes were made in plant container size and spacing to improve bud quality and quantity in white spruce and balsam fir; plans for a new animal facility to meet federal and provincial regulations were drawn up and cost estimates were obtained.

PROJECTIONS: During 1989-90, all plant requirements for the Institute will be met; all greenhouse services required will be provided; changes to the small animal facility to meet regulatory requirements will be overseen, and continued care will be provided to the small animal population. ♦

FP-40-6 AIRCRAFT SERVICES

PROJECT STAFF: A. Robinson (*Study Leader*)

OBJECTIVES: To provide aircraft services to those FPMI projects whose research on pesticides requires aerial application.

ACHIEVEMENTS: During 1988-89, the aircraft, associated spray equipment and hangar were maintained in good condition; plans for a

portable spray mixing rig were drawn up and aircraft services were provided for spray applications of *B.t.*, gypsy moth virus and other pest control products or facsimiles.

PROJECTIONS: During 1989-90, the aircraft and associated equipment and facilities will be maintained in good order; aerial applications will be made for a range of FPMI and cooperator studies and modifications to spray equipment will be made as required. ♦

FP-40-7 TECHNICAL SERVICES

PROJECT STAFF: W.J.G. Beveridge (*Study Leader*)

OBJECTIVES: To provide technical services to FPMI projects, including design, construction, and repair of scientific equipment.

ACHIEVEMENTS: During 1989-90, the FPMI wood working shop and testing facilities were organized and maintained. Technical assistance, such as the design, construction and repair of various scientific equipment was provided as needed.

PROJECTIONS: During 1989-90, design, construction and repair of scientific equipment will continue. ♦

INFORMATION & TECHNICAL SERVICES

No research can be considered complete until the results have been transferred effectively to potential users. Because FPPI is closely associated with other federal departments, other governments, private industry, and the Canadian public, it is essential that results from the FPPI research program reach the publics for which they are intended. The Scientific Editing and Information Services Unit is responsible for developing and modifying the packaging and format of reports to meet changing demand; providing an editorial capability in both official languages; preparing and issuing regularly scheduled publications according to schedule; and, responding to requests for information.

The Information and Technical Services Unit at the Institute provides these and other services, contributing in a significant manner to the overall program at FPPI. ♦

FP-93 SCIENTIFIC EDITING AND INFORMATION

PROJECT STAFF: K. Jamieson (*Project Leader*), S. Mantulak

OBJECTIVES: To publish and disseminate scientific and technical information that arises from the Institute's program in the most appropriate form to facilitate the transfer of forest pest management science and technology to user groups.

ACHIEVEMENTS: During 1988-89, the project handled the publication of 20 journal papers, 3 English information reports, 1 french information report, 15 miscellaneous reports, 3 newsletters, and one entire Proceedings. Five submissions for Symposiums and Proceedings and 14 book chapters were reviewed, edited and submitted. Also, during this period, 1,202 information reports, 2,498 journal articles, 102 technical notes, 306 french publications, as well as countless miscellaneous publications were distributed. An Interleaf electronic publishing system was purchased. Participation continued in FCOR summer tour program.

PROJECTIONS: During 1989-90, effective and efficient editing and production of FPPI publications will continue. Electronic publishing will be introduced and used to improve the quality of FPPI publications. Involvement will continue in summer tour program. Refinements will be made to the museum display. ♦

ADMINISTRATION & COMMON SUPPORT SERVICES

Administrative Support Services (materiel management, records management, office services, fleet management, operation and maintenance of physical plant) and financial services are provided to both the Forest Pest Management Institute and Forestry Canada – Ontario Region through one administrative unit carried on the FCOR allocation, but responsible to the Directors General of both establishments. Integration of these services has been total since 1978. Some economies in staff have resulted. These integrated services have functioned in a highly satisfactory manner since their inception and are considered the most appropriate organizational option for sister establishments of the same service sharing the same physical facility.

Integrated joint library services are provided to both establishments in a similar fashion with permanent library staff carried on the Forestry Canada – Ontario Region allocation. This too, has resulted in some economies in both staff and library space.

As opportunities present themselves in the future, the desirability of further integration of common support services will be investigated thoroughly with Forestry Canada – Ontario Region. ♦

FP-94 LIBRARY SERVICES

PROJECT STAFF: (FCOR)

OBJECTIVES: To develop, maintain and improve a research library commensurate with the changing requirements of the combined programs of Forestry Canada, Ontario Region and the Forest Pest Management Institute.

ACHIEVEMENTS: During 1988-89, effective and efficient library service continues to be provided to FPMI and FCOR staff. The librarian and library staff completed training on the Sydney Automated Library System as planned; information services and demonstrations on the Sydney facility were held for management and staff; a journal subscription review was completed, unnecessary journals were weeded out and new ones added as required.

PROJECTIONS: During 1989-90, efficient and effective library services will continue to be provided; remaining circulation records will be converted to the Sydney system; training guides for the Sydney system will be developed, and shelving requirements and arrangements for the library will be reviewed. ♦

FP-97 ADMINISTRATION, FINANCIAL AND ENGINEERING SERVICES

PROJECT STAFF: (FCOR)

OBJECTIVES: To provide effective and efficient administrative and financial services in support of FPMI's program; to provide adequate physical facilities within which the Forest Pest Management Institute's R&D program can be carried out and to ensure that these are operated and maintained in the most efficient and effective manner.

ACHIEVEMENTS: During 1988-89, administrative services were provided in an effective and efficient manner; a physical inventory of materiel was carried out; WHMIS was partially implemented; an updated mailing machine was installed; new procedures for Deposit and Trust accounts were implemented; the FPMI headerhouse and aviary were upgraded, and asbestos insulation was removed from the FPMI headerhouse.

PROJECTIONS: During 1989-90, the administration, financial and engineering units will continue to provide effective and efficient service; WHMIS should be fully implemented; the Terradata Financial System will be introduced and, the Institute's animal care facility will be upgraded to meet requirements of the Canadian Council of Animal Care. ♦

APPENDICES

FOREST PEST MANAGEMENT INSTITUTE

EXPENDITURES 1988-89 (\$'000's)

PROGRAM AREA	PERSON YEARS	SALARIES	OPERATIONS & MAINTENANCE	CAPITAL	TOTAL
Management	5.0	450.8	59.1	2.7	512.6
Finance & Administration	-	-	220.6	46.3	266.9
Physical Plant ¹	-	-	299.3	20.7	320.0
Sci. Editing & Information Library ¹	2.0	67.0	25.4	-	92.4
Complementary Services	-	-	65.1	30.0	95.1
Microbial Control Agents	16.0	462.9	68.8	339.7 ²	871.4
Biological Interactions	16.0	593.8	125.2	33.3	752.3
Physiological Mechanisms	7.0	276.4	30.3	26.0	332.7
Pesticide Toxicology & Efficacy	6.0	266.3	32.4	16.4	315.1
Application Technology	14.0	536.5	76.7	12.6	625.8
Environmental Concerns	4.0	145.0	15.4	46.9	207.3
	12.0	382.2	51.4	35.6	469.2
TOTAL:	82.0	3,180.9	1,069.7	610.2	4,860.8

¹ Common, shared service with FCOR; staff carried on FCOR complement

² Includes replacement of transmission electron microscope (\$319.7)

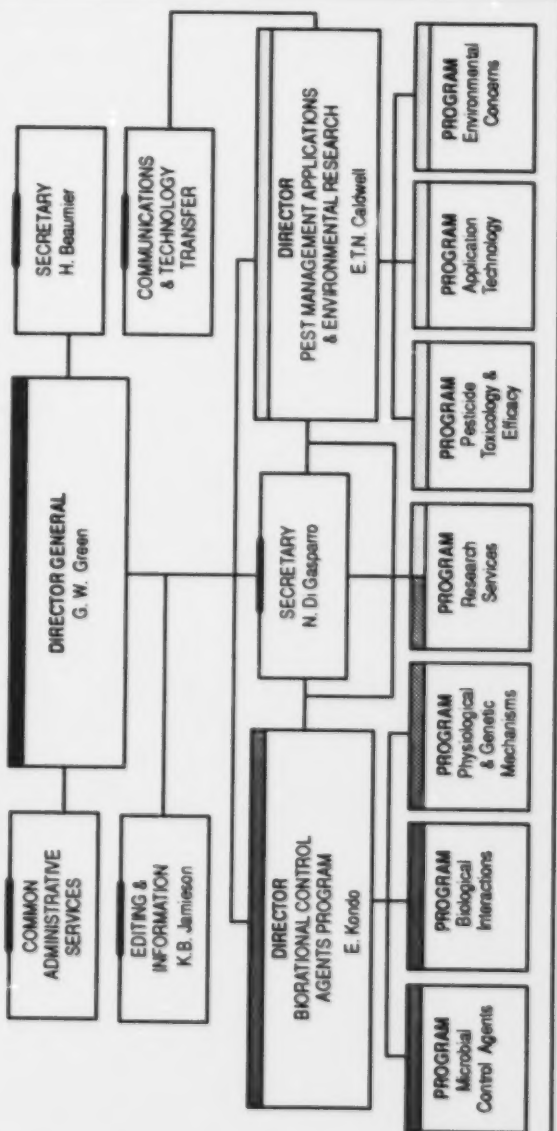
FOREST PEST MANAGEMENT INSTITUTE

RESEARCH AND DEVELOPMENT

CONTRACTS 1988-89

CONTRACTOR	TITLE	AMOUNT (\$)	SCIENTIFIC AUTHORITY
L. Gringorten Sault Ste. Marie	Bioassay of B.1. gene products	35,250	K. van Frankenhuyzen (FP-10)

FOREST PEST MANAGEMENT INSTITUTE / 1988 - 1989



**FOREST PEST
MANAGEMENT INSTITUTE**
ORGANIZATION & STAFF LISTING

**DIRECTOR
GENERAL**

Dr. G.W. Green
Secretary: H. Beaumier

**PROGRAM
DIRECTORS**

Mr. E.T.N. Caldwell
CHEMICAL CONTROL
AGENTS PROGRAM

Dr. E. S. Kondo
BIORATIONAL CONTROL
AGENTS PROGRAM

Secretary: N. DiGasparro

**ADMINISTRATIVE
OFFICER**

D. Gair
Forestry Canada
Ontario Region

**SCIENTIFIC
EDITING**

K. B. Jamieson, Editor
S. Mantulak

(as of April 1, 1988)

RESEARCH & DEVELOPMENT PROJECTS

MICROBIAL CONTROL AGENTS

Program Director: Dr. E.S. Kondo

PROJECT NO.	TITLE	SCIENTIFIC STAFF	TECHNICAL STAFF
FP-10	Bacterial Pathogens	Dr. K. van Frankenhuysen PROJECT LEADER vacant Research Scientist	C. Budeau R. Milne C. Nystrom T. Wright
FP-11	Fungal Pathogens	Dr. D. Tyrrell PROJECT LEADER	K. Humphries M. Walton
FP-13	Viral Pathogens	Dr. J.C. Cunningham PROJECT LEADER Dr. B.M. Arif Dr. W.J. Kaupp Mr. P.J. Jamieson	K. Brown P. Ebling H. Lauzon

RESEARCH & DEVELOPMENT PROJECTS

BIOLOGICAL INTERACTIONS

Program Director: Dr. E.S. Kondo

PROJECT NO.	TITLE	SCIENTIFIC STAFF	TECHNICAL STAFF
FP-20	Insect Pathogens <u>in vitro</u>	Dr. S.S. Sohi PROJECT LEADER	G. Caputo B. Cook
FP-22	Immunochemistry	Dr. A. Pang PROJECT LEADER	B. Mathieson
FP-23	Biological Systems Analysis	Dr. R.A. Fleming PROJECT LEADER	T. Burns

RESEARCH & DEVELOPMENT PROJECTS

PHYSIOLOGICAL & GENETIC MECHANISMS

Program Director: Dr. E.S. Kondo

PROJECT NO.	TITLE	SCIENTIFIC STAFF	TECHNICAL STAFF
FP-30	Insect Pheromones	Dr. G.G. Grant PROJECT LEADER	D. Frech D. Lombardo
FP-31	Insect Growth Regulators	Dr. A. Retnakaran PROJECT LEADER	L.F. Smith W. Tomkins

RESEARCH & DEVELOPMENT PROJECTS

PESTICIDE TOXICOLOGY & EFFICACY

Program Director: Mr. E.T.N. Caldwell

PROJECT NO.	TITLE	SCIENTIFIC STAFF	TECHNICAL STAFF
FP-50	Insecticide Toxicology	Dr. B.V. Helson PROJECT LEADER	D. Comba J. McFarlane
FP-51	Insecticide Field Efficacy	Mr. B. L. Cadogan PROJECT LEADER	R. Scharbach B. Zylstra
FP-52	Plantation Pest Management	Dr. J. Turgeon PROJECT LEADER Mr. P. de Groot	N. Nelson A. Obarynskyj
FP-53	Herbicide Physiology	Dr. R. Prasad PROJECT LEADER	J. Studens
FP-54	Herbicide Development & Use	Dr. P. Reynolds PROJECT LEADER	D. Pitt

RESEARCH & DEVELOPMENT PROJECTS

APPLICATION TECHNOLOGY

Program Director: Mr. E.T.N. Caldwell

PROJECT NO.	TITLE	SCIENTIFIC STAFF	TECHNICAL STAFF
FP-61	Pesticide Formulations	Dr. A. Sundaram PROJECT LEADER	J. Leung
FP-62	Application Technology for Forest Pesticides	Dr. N. Payne PROJECT LEADER	D. Curry

RESEARCH & DEVELOPMENT PROJECTS

ENVIRONMENTAL CONCERNS

Program Director: Mr. E.T.N. Caldwell

PROJECT NO.	TITLE	SCIENTIFIC STAFF	TECHNICAL STAFF
FP-70	Environmental Impact	Mr. S. Holmes PROJECT LEADER Mr. K. Barber Mr. D. P. Kreutzweiser Ms. R. Millikin	S. Capell vacant technician
FP-71	Insecticide Chemical Accountability	Dr. K.M.S. Sundaram PROJECT LEADER	J. Broks R. Nott
FP-72	Herbicide Chemical Accountability	Mr. D. Thompson PROJECT LEADER	L. MacDonald B. Staznik

RESEARCH & DEVELOPMENT PROJECTS

COMPLEMENTARY SERVICES

Program Directors: Mr. E.T.N. Caldwell & Dr. E.S. Kondo

PROJECT NO.	TITLE	SCIENTIFIC STAFF	TECHNICAL STAFF
FP-40-1	Insect Production	Mr. B. McCron STUDY LEADER	K. Barrett L. Harwood H. Wigney S. White
FP-40-2	Pathogen Production	Mrs. B. Cunningham STUDY LEADER	
FP-40-3	Disease Diagnosis	Dr. G. Wilson STUDY LEADER	vacant technician
FP-40-4	Electron Microscopy	Mr. J.A. MacDonald STUDY LEADER	A. Brownwright
FP-40-5	Plant Production	Mr. D.A. Buckley STUDY LEADER	L.S. MacLeod
FP-40-6	Aircraft Services	Mr. A. Robinson STUDY LEADER	
FP-40-7	Technical Services	Mr. W.J.G. Beveridge	

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